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The First *Alora* H. Adams, 1861 (Gastropoda: Epitoniidae) from Western South America: Unique Miocene Records

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Abstract. *Alora teresmonile*, sp. nov., from middle and upper Miocene beds of the Pisco Basin in southern Peru is the first epitoniid of its genus to be found in western South America and the first fossil species of *Alora* from anywhere. A Miocene Tethyan distribution probably accounts for the pattern of widely separated Recent *Alora* taxa. In southern Peru, *A. teresmonile* first appeared as part of an evolutionarily transitional molluscan fauna living in a coastal upwelling regime during a time of globally decreasing sea surface temperatures.

INTRODUCTION

Alora H. Adams, 1861, includes small, thin-shelled, often globose epitoniids with spiral and axial sculpture (Keen, 1969; DuShane, 1974; Weil et al., 1999; Nakayama, 2003). Extant species have been reported from Panama and Mexico [*A. gouldii* (A. Adams, 1857); *A. billeeana* (DuShane & Bratcher, 1965)], southeast Asia [(*A. annulata* (Kuroda & Ito, 1961)], Japan [*A. annulata*; *A. kiiensis* Nakayama, 2000; *A. reticulata* (Habe, 1962)], the North Atlantic Ocean [*A. retifera* Bouchet & Warén, 1986; *A. tenerrima* (Dautzenberg & Fischer, 1896)], Brazil [*A. retifera* (S. Vanin, personal communication, 2007; http://www.conchasbrasil.org.br, March, 2007)], and East Africa (*A. rapunculus* Kilburn, 1975). A single fossil species has been identified, the Miocene *A. minihagali* (Deraniyagala, 1956) from Sri Lanka (Neville, 1997).

This paper reports the first *Alora* of any age from western South America, contradicts the assignment of the Sri Lankan Miocene species to *Alora*, and briefly addresses the biogeographic implications of Miocene *Alora* from southern Peru.

GEOLOGY

The stratigraphy of the Cenozoic Pisco Basin in southern Peru has been described by DeVries (1998). The older specimens of *Alora* were found in the lower third of the Pisco Formation in the Río Ica valley. The presence of the gastropods *Testallium cepa* (Sowerby, 1846), *Concholepas unguis* DeVries, 1995, and *Acanthina katzi* Fleming, 1972, in the same sandstone beds as *Alora* confirms an early to early middle Miocene age for the epitoniid species (DeVries, 1995, 2003; DeVries & Schrader, 1997; Vermeij & DeVries, 1997), an age further constrained to the middle Miocene by the co-occurrence of *Turritella infracarinata* Gryzbowski, 1899 (DeVries, 2007). The younger specimens of *Alora* were found in tuffaceous beds of the Pisco Formation in the smaller Sacaco Basin at Aguada de Lomas. The base of the Aguada de Lomas section is dated by ^{40}K-^{40}Ar at about 9 to 8 Ma, whereas the upper part of the section lies below a very late Miocene unconformity (Muizon & DeVries, 1985), thereby suggesting an age of about 7-6 Ma for the *Alora* specimens.

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MATERIALS AND METHODS

Fossils described in this study were found by the author. Measurements of length (L) and width (W) are in millimeters; those enclosed by parentheses indicate sizes for broken or deformed specimens.

Abbreviations for depositories for fossil specimens are as follows: MUSM INV – Departamento de Paleontología de Vertebrados, Museo de Historia Natural, Universidad Nacional Mayor de San Marcos, Lima, Peru; UWBM – Burke Museum of Natural History and Culture, University of Washington, Seattle, USA.

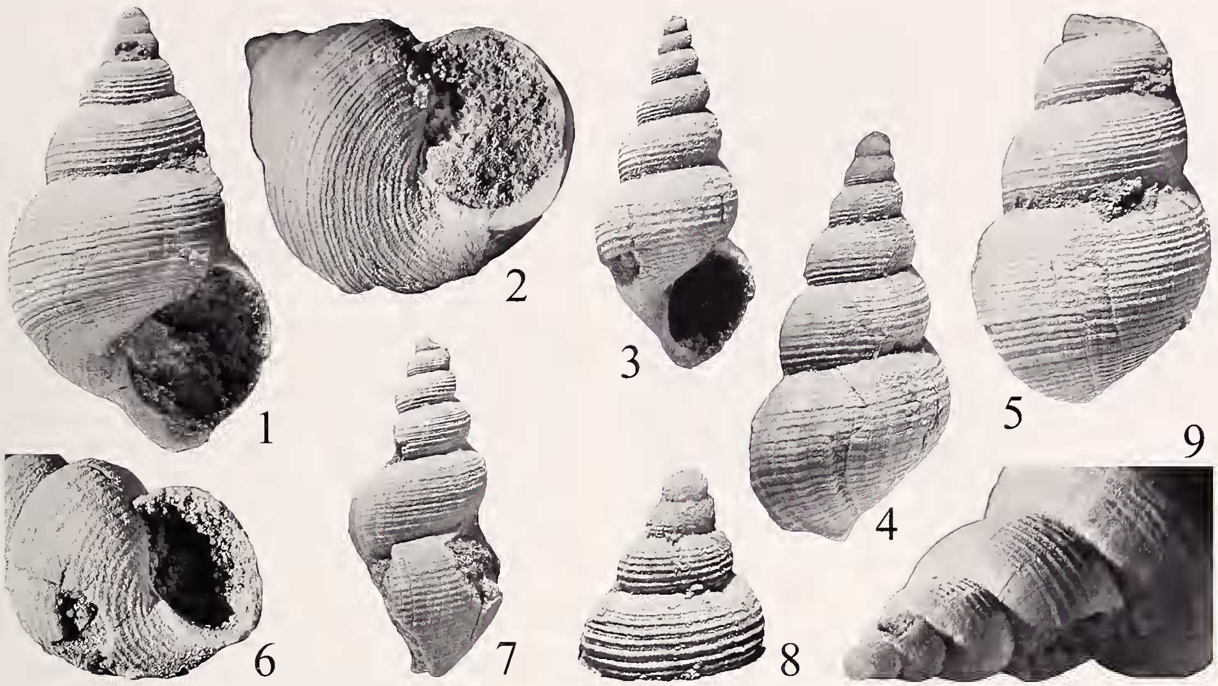
SYSTEMATIC PALEONTOLOGY

Family Epitoniidae S. S. Berry, 1910

Alora H. Adams, 1861

Type species: (by monotypy) *Trichotropis gouldii* A. Adams, 1857.
Teramachiacirsa Kuroda & Ito, 1961, p. 263.

Discussion: *Alora* H. Adams, 1861, was created by Adams for his brother's recently described species, "*Trichotropis gouldii*" A. Adams, 1857. H. Adams (1861) noted the absence of a trichotropine siphonal canal on the '*gouldii*' specimen. Keen (1969) recommended the transfer of *Alora* from Janthinidae to



Figures 1–9. *Alora teresmonile*, sp. nov. DV 1021-3, southern Peru, middle Miocene. All but UWBM 98113 are paratypes. Figure 1. UWBM 98113, holotype, apertural view. Length is 10.7 mm. Figure 2. UWBM 98113, oblique basal view. Width is 6.0 mm. Figure 3. UWBM 98114, apertural view. Length is 9.6 mm. Figure 4. MUSM INV 154, abapertural view. Length is 10.9 mm. Figure 5. MUSM INV 155, abapertural view. Length is 10.0 mm. Figure 6. UWBM 98114, oblique basal view showing tiny umbilicus. Width is 4.1 mm. Figure 7. MUSM INV 156, lateral view. Length is 11.1 mm. Figure 8. UWBM 98113, protoconch and early spire whorls. Visible length is 1.3 mm. Figure 9. UWBM 98113, protoconch and early spire whorls. Note smooth shoulder of later whorls.

Epitoniidae and further noted the synonymy of *Recluzia insignis* Pilsbry & Lowe, 1932, with *A. gouldii.*

The type species of *Alora* and other Recent Pacific species, notably *A. billeeana* and *A. reticulata*, have pronounced cancellate sculpture. Other species, including *A. annulata*, *A. rapunculus*, and *A. kiiensis*, have subdued axial costae and well developed spiral cords.

Alora teresmonile, sp. nov.

Figures 1–9

Diagnosis: Up to 50 spiral cords on body whorl of adult specimens, interspaces on earlier whorls having become new spiral cords; cords more widely spaced or absent on shoulder. Axial sculpture obsolete.

Description: Very thin-shelled; shell length to 37 mm. Spire angle variable, as little as 16 degrees, usually 22 to 25 degrees, late Miocene specimens 30 to 40 degrees. Whorls convex to globose, evenly rounded; sutures impressed. Protoconch conical with two smooth whorls. Teleoconch of about six to seven whorls. Axial sculpture of numerous irregularly spaced orthocline to slightly prosocline growth lines, some strengthened to form weak axial costae, especially on early whorls; some growth lines variably sinuous in response to growth breaks. Spiral sculpture of eight to nine evenly spaced, sharply rounded spiral cords visible on spire whorls, often becoming wider and more widely spaced or obsolete on shoulder. Interspaces become secondary or primary spiral cords on penultimate and ultimate whorls, resulting in about 40 to 50 low rounded spiral cords on body whorl between base and posterior suture; spiral cords closely spaced anteriorly, often widely spaced or obsolete on shoulder. Aperture ovate, strongly spatulate posteriorly to form a pseudosiphonal canal. Outer lip thin. Inner lip not continuous; columella slightly thickened, vertical to arcuate, reflected at anterior end, inclined adaperturally to merge with apertural floor. Umbilicus absent or slightly open.

Type Locality: Locality-sample DV 1021-3, hillside on the east side of Quebrada Gramonal, in lagoonal sandstone lag deposits, lower Pisco Formation, Ica Valley, southern Peru (Figure 10). Middle Miocene.

Discussion: Specimens of *Alora teresmonile* share with specimens of other species of *Alora* a very thin shell, a reflected and adaperturally slanted columella, and markedly convex whorls. Most middle Miocene speci-

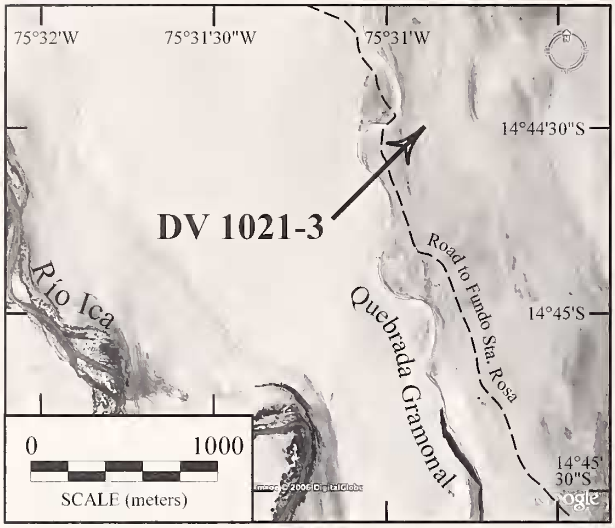


Figure 10. Type locality (DV 1021-3) of *Alora teresmonile*, sp. nov.

mens of *A. teresmonile* have spire angles comparable to those of specimens of *A. gouldii* and *A. kiiensis*; late Miocene specimens have spire angles more like those of the globose *A. annulata* and *A. rapunculus*. Three modes in the distribution in Peruvian spire angles in middle and late Miocene specimens might indicate the existence of three species, but too few examples have been collected to presently justify such a distinction.

Middle Miocene specimens of *Alora teresmonile* are found in coarse-grained sandstones thought to represent lag deposits covering the floor of lagoons and scour-and-fill deposits that may represent the ebb and flood channels to the lagoons. These sandstones and intervening finer-grained sandstones contain a diverse molluscan fauna as well as rare fragments of crinoids and partial or whole skeletons of mysticete whales and *Isurus* sharks. The late Miocene specimens are found in a sequence of massive, bioturbated, and cross-bedded sandstones with intercalated horizons of *Mulinia* bivalves, oysters, and erosive disconformities with pebbles and pumice fragments, all deposited in the lee of a paleo-island composed of pre-Cenozoic igneous rock (Muizon & DeVries, 1985). The inferred shallow depths of these late and middle Miocene *Alora* habitats contrast with the deep-water habitat of some modern *Alora* taxa [e.g., *A. annulata*, 100–300 m water depth (DeVries, collection); *A. retifera*, 1250 m water depth (Bouchet & Warén, 1986); *A. tenerrima*, 1385 m water depth (Dautzenberg & Fischer, 1896)], but are comparable to the shallow waters presently inhabited by individuals of *A. gouldii* and *A. billeeana* in Panama and the Gulf of California (Hinojosa-Arango & Riosmena-Rodríguez, 2004) and *A. reticulata* in Japan (Nakayama, 2003).

Etymology: 'teres,' Latin adjective for 'smooth,' and 'monile,' Latin noun for 'collar' or 'necklace,' referring to the diminishment of spiral sculpture close to the posterior suture of each whorl.

Material: UWBM 98113, DV 1021-3, middle Miocene, holotype, L 10.7, W 6.0; MUSM INV 154, DV 1021-3, paratype, L (10.9), W 5.4; MUSM INV 155, DV 1021-3, paratype, L (10.0), W 5.8; MUSM INV 156, DV 1021-3, paratype, L 11.1, W 6.0; MUSM INV 157, DV 1021-3, paratype, L 4.9, W 2.4; MUSM INV 158, DV 1655-4, middle Miocene, L 14.7, W 7.5; MUSM INV 161, DV 563-1, late Miocene, L (31.9), W 19.1; MUSM INV 162, DV 563-1, L 16.6, W 10.0; UWBM 98114, DV 1021-3, paratype, L 9.6, W 4.1; UWBM 98115, DV 1655-4, L 22.5, W (10.5); UWBM 98116, DV 1307-1, middle Miocene, L 9.3, W 5.1; UWBM 98207, DV 563-1, late Miocene, L 36.5, W 20.1; UWBM 98208, DV 563-1, L (19.0), W 11.9; UWBM 98209, DV 563-1, L 17.3, W 9.6. DeVries collection, DV 1021-3, lot of 8.

Occurrence: Middle to late Miocene: southern Peru.

DISCUSSION

Alora teresmonile is ostensibly the second fossil species of *Alora*. Efforts to examine material of the only other reported fossil species of *Alora*, the Miocene *A. minihagali*, were unsuccessful; the type specimen has been lost from the National Museum of Natural History in Colombo, Sri Lanka (K. Manamendra-Arachchi, *fide* R. Pethiyagoda, personal communication, March, 2007). A description and figure of the type specimen (Spoila Zeylanica 28(1):3, pl. 2, fig. 2c; 1956) call attention to strong and broad axial ribs, about 14 in number, that are not consistent with Neville's (1997) assignment of the species to the weakly and finely cancellate *Alora*; Neville (personal communication, April, 2007) is now of the same opinion. Thus, with the Sri Lankan species removed from *Alora*, the Peruvian species constitutes the only documented fossil example of the genus.

Recent species of *Alora* are widely scattered throughout the world's oceans in shallow and deep water at tropical and subtropical latitudes, probably indicating an equally widespread ancestral distribution with dispersal aided by circumtropical Tethyan circulation. The ease of dispersal for some *Alora* species is demonstrated by the modern pan-Atlantic distribution of *A. retifera* and pan-Pacific distribution of *A. billeeana* (Okutani, 2000; Nakayama, 2003). Given the close association of epitoniids with their coelenterate hosts, the dispersal of *Alora* taxa probably reflects the dispersal capacity of those hosts.

Alora appeared in the Pisco Basin at the same time that other taxa (e.g., *Turritella infracarinata*) arrived from northern Peru and Ecuador (DeVries, 2007). The middle Miocene was a time of faunal disruption in southern Peru, when global sea surface temperatures were decreasing and when a molluscan fauna that had persisted in southern Peru since the latest Oligocene was being replaced by the antecedents of the 'modern' fauna of the Peruvian Faunal Province (DeVries, 2002). This limited invasion from the north was repeated near the end of the Pliocene under similar climatic and oceanographic circumstances (DeVries, 2002).

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Appendix

Locality-samples

DV 653-1	Northeast corner of Aguada de Lomas, northern Sacaco Basin, at 87 m in measured section, probably equivalent to 180 m in measured section of DV 562-1. 15°28′49″S, 74°48′19″W (Acarí 1:100,000 quadrangle). Pisco Formation, upper Miocene.
DV 1021-3	Hillside on the east side of Quebrada Gramonal, in lagoonal sandstone lag deposits, Ica Valley, southern Peru. 14°44′19″S, 75°31′02″W (Lomitas 1:100,000 quadrangle). Lower Pisco Formation, middle Miocene.
DV 1307-1	East of mouth of Quebrada Gramonal, three-meter wide channel-fill bioclastic deposit, 14°45′48″S, 75°30′23″W (Lomitas 1:100,000 quadrangle). Lower Pisco Formation, middle Miocene.
DV 1655-4	East of 'labyrinth' dune field, east of lower reach of Río Ica, 14°50′16″S, 75°27′29″W (Lomitas 1:100,000 quadrangle). Lower Pisco Formation, middle Miocene.